Back to the Future: A Mesh Balloon for Wide-necked Brain Aneurysm Endovascular Treatment

Steven W. Hetts, MD

Dr Steven Hetts is a professor in the Division of Neurointerventional Radiology in the Department of Radiology and Biomedical Imaging at the University of California, San Francisco. His clinical practice focuses on endovascular treatment of cerebrovascular disease and central nervous system tumors in children and adults. He develops endovascular devices and imaging techniques and performs clinical outcomes research. He has been an NIH principal investigator for 10 years.

Brain aneurysms are prevalent—up to 3% of adults may have an unruptured brain aneurysm, as is increasingly recognized due to more frequent neuroimaging for a variety of indications (1). Although many incidentally discovered asymptomatic brain aneurysms will not rupture, 6.1 per 100 000 people worldwide do suffer an aneurysmal subarachnoid hemorrhage each year (2). Of those patients whose brain aneurysms do rupture, up to 75% end up dead or chronically disabled. Given the devastating outcomes of brain aneurysm rupture, there has long been an impetus on the part of physicians and patients for treatment of aneurysms not only after they have ruptured, but also before they have ruptured. Although open surgical techniques for aneurysm repair have been available for almost a century, the last 40 years have witnessed a proliferation of minimally invasive endovascular techniques to treat brain aneurysms, thus preventing their rupture or rerupture.

Many ruptured and unruptured brain aneurysms can be treated successfully and durably with endovascular devices (3). Minimally invasive aneurysm treatment has come a long way since the first cases of endovascular balloon occlusion of surgically inaccessible brain aneurysms in the late 1970s and early 1980s (4,5). Embolic detachable coils—the standard for endovascular aneurysm treatment since the early 2000s—will usually self-retain within aneurysms, followed by thrombosis and durable occlusion of the aneurysm. However, some aneurysms have a broad attachment to the parent artery (“wide-neck aneurysms,” with a connection of ≥4 mm to the parent artery or a ratio of aneurysm dome to neck of <2). For wide-neck aneurysms, coils can herniate into the parent artery and cause adjacent parent artery thrombosis, distal thromboemboli, or even coil dislodgement and distal coil embolization to other arteries in the brain.

Placing a stent in the parent artery across the neck of the aneurysm provides a scaffolding that can maintain coils within the aneurysm and out of the parent artery. Stent-assisted coil (SAC) placement was described in the 1990s (6). SAC placement has become a mainstay for the treatment of wide-necked brain aneurysms, with multiple stents developed specifically for navigation to and deployment in the small tortuous cerebral arteries.

SAC placement is usually limited to unruptured aneurysm treatment because the metal stent residing in the parent artery can cause parent artery thrombosis or distal thromboemboli unless the patient is treated with dual antiplatelet medications (DAPT), often consisting of aspirin plus clopidogrel or a newer antiplatelet agent. Although DAPT often can be safely discontinued after endothelial cells have grown over the stent, this generally means patients are on DAPT for 6 months or longer after SAC placement. Over the last 15 years, flow-diverting stent (FDS) devices have been shown to produce aneurysm thrombosis when deployed across the neck of brain aneurysms, often without the need for adjunctive coils.

Both SAC and FDS placement require DAPT to prevent parent artery thrombotic complications, thus providing the impetus to develop new brain aneurysm treatment devices that dwell completely within the aneurysm. These new-generation intrasaccular aneurysm treatment devices have elements of flow-disrupting metallic mesh incorporated into either coil-like (eg, Citadel; Stryker) or balloon-like (eg, Woven EndoBridge [WEB]; MicroVention) configurations.

In this issue of *Radiology*, Adeeb et al (7) describe the extension of a balloon-like metallic mesh device, WEB, developed for treatment of brain aneurysms arising at vascular branch points to those arising from the sidewall of arteries in the brain. Branch-point aneurysms, or bifurcation aneurysms, are particularly challenging to treat. Flow jets directed at the aneurysm from the parent artery as well as outflow to distal branches both hinder stasis in the aneurysm. This can lead to increased rates of coil compaction and long-term aneurysm recanalization. WEB has performed well in on-label use in branch-point aneurysms, often preventing aneurysm recanalization beyond small stable neck remnants with concomitantly low rupture and rerupture rates (8). WEB is now being applied to wide-necked sidewall aneurysms that otherwise would require SACs or FDSs and attendant DAPT.

From the Department of Radiology & Biomedical Imaging, Division of Interventional Neuroradiology, University of California San Francisco, 505 Parnassus Ave, L-351, San Francisco, CA 94143-0628. Received December 30, 2021; revision requested January 12, 2022; revision received January 28; accepted February 2. **Address correspondence to** the author (e-mail: *steven.hetts@ucsf.edu*).

Supported by the National Institutes of Health (grant R01EB012031).

Conflicts of interest are listed at the end of this article.

See also the article by Adeeb et al in this issue.

Radiology 2022; 304:383–384 • https://doi.org/10.1148/radiol.213306 • Content codes: NR IR •

Because flow in sidewall aneurysms is generally lower than in branch-point aneurysms, a priori it would be expected that WEB would cause thrombosis in sidewall aneurysms at least as well as in branch-point aneurysms. The authors confirmed this by matching off-label sidewall aneurysm cases to on-label bifurcation cases in a large multicenter retrospective database accrued over 10 years. The authors used propensity score matching to perform initial analyses based on variables shown to affect angiographic or clinical outcomes: age, pretreatment modified Rankin Scale score of neurologic disability, aneurysm rupture status, aneurysm location, prior treatment, neck width, dome height, dome width, presence of a daughter sac arising from the main aneurysm, and incorporation of a branch artery in the aneurysm. Multiple aneurysms were excluded, and matched cases were then compared between bifurcation and sidewall locations and between ruptured and unruptured initial presentations.

Immediate adequate aneurysm occlusion according to the WEB occlusion scale (equivalent to complete Raymond-Roy grade 1 or small neck remnant Raymond-Roy grade 2 results for coils) was higher ($P < .001$) for sidewall aneurysms (66%) than for bifurcation aneurysms (43%). There was a lower rate (P = .05) of thromboembolic complications for sidewall aneurysms (2.7%) than for bifurcation aneurysms (8.4%), as the latter have branches arising adjacent to the aneurysm neck that are at higher risk for being covered by the WEB device itself or for an intra-aneurysmal clot to propagate to the adjacent branch. There was a trend (P = .06) toward adjunctive coil use in the sidewall group (5.4%) versus the bifurcation group (2.3%).

There were no differences between bifurcation and sidewall location in terms of technical complications (4%) or periprocedural hemorrhage (3%). This is encouraging, as a particular challenge of the WEB device is that it is inserted through the microcatheter as a constrained, stiff, wire-like device initially that then fans out to become a soft, ball-shaped mesh device that apposes the aneurysm walls to anchor in place. Perforations of the aneurysm during the initial deployment are a particular concern but did not appear to be higher in the sidewall group than in the bifurcation group, despite the technical challenge of steering the WEB device into aneurysms at an angle to the parent artery. Because the stiff WEB device can straighten out a curved microcatheter tip during initial deployment, the authors appropriately note the challenge of treating sidewall aneurysms arising at acute or recurrent angles from the parent artery and advise practitioners to take neck angle into account when selecting cases for treatment.

At last angiographic follow-up, both sidewall and bifurcation aneurysms demonstrated progressive occlusion, with 89% of sidewall aneurysms and 85% of bifurcation aneurysms adequately occluded at a median of 9 and 11 months, respectively, after surgery. It is important to note, however, that subgroup analysis in Table 6 of the article by Adeeb et al (7) suggested that ruptured sidewall aneurysms had less progressive occlusion (rising from 72% immediate to 87% adequate occlusion at last follow-up) than ruptured bifurcation aneurysms (rising from 59% to 95%). Retreatments were performed in 11% and 7% of sidewall and bifurcation aneurysms, respectively, which did not differ significantly. No aneurysms reruptured during the follow-up period. Clinical outcomes as assessed by modified Rankin Scale score and all-cause mortality (3.4% for bifurcation and 2% for sidewall aneurysms) were similar for the two groups. These outcomes are comparable to those achieved with contemporary SAC (9) and FDS techniques (10).

Inclusion of sidewall wide-necked saccular aneurysms represents successful diffusion of WEB technology beyond its initial target population. The current study supports the successful use of WEB in sidewall as well as bifurcation anatomy. The most compelling niche of cases for WEB will continue to be ruptured saccular wide-necked aneurysms not amenable to coil placement in which DAPT is relatively or absolutely contraindicated. Relatively short procedure times for WEB in these patients will be weighed against somewhat low immediate complete angiographic occlusion, the latter being an inherent feature of flow-diverting and flow-disrupting mesh devices. A less compelling but broader use for WEB will be in unruptured wide-necked saccular aneurysms in which DAPT is undesirable due to side effects such as systemic bleeding or excessive bruising. For that population, prospective and randomized comparison of intrasaccular flow disruptors to technologies that rely on parent artery adjunctive (SAC) or primary (FDS) devices would help guide physicians and patients over the next decade.

Disclosures of conflicts of interest: S.W.H. Research grants and contracts to institution from Stryker, Siemens, the National Institutes of Health, and Route 92; royalties to institution from Filtro for licensed intellectual property; clinical events committee member or data safety and monitoring committee member for Cerenovus, MicroVention, Terumo, and Imperative; leadership roles with the Society of NeuroInterventional Surgery and American College of Radiology; stock in ThrombX.

References

1. Hackenberg KAM, Etminan N. Neurovascular disease, diagnosis, and therapy: brain aneurysms. Handb Clin Neurol 2021;176:121–134.
2. Etminan N, Macdonald RL. Neurovascular disease, diagnosis, and therapy: subarachnoid hemorrhage and cerebral vasospasm. Handb Clin Neurol 2021;176:135–169.
3. Fatania K, Patankar DT. Comprehensive review of the recent advances in devices for endovascular treatment of complex brain aneurysms. Br J Radiol 2022;95(1129):20210538.
4. Heifetz MD, Hieshima GB, Mehringer CM. Preliminary report of a hollow-centered balloon for intravascular occlusion of intracranial aneurysms or arteriovenous fistulas. Technical note. J Neurosurg 1980;53(2):262–265.
5. Higashida RT, Halbach VV, Dowd CF, Barnwell SL, Hieshima GB. Intracranial aneurysms: interventional neurovascular treatment with detachable balloons--results in 215 cases. Radiology 1991;178(3):663–670.
6. Higashida RT, Smith W, Gress D, et al. Intravascular stent and endovascular coil placement for a ruptured fusiform aneurysm of the basilar artery. Case report and review of the literature. J Neurosurg 1997;87(6):944–949.
7. Adeeb N, Dibas M, Diestro JDB, et al. Multicenter study for the treatment of sidewall versus bifurcation intracranial aneurysms with use of Woven EndoBridge (WEB). Radiology 2022;304(2):372–382.
8. Pierot L, Costalat V, Moret J, et al. Safety and efficacy of aneurysm treatment with WEB: results of the WEBCAST study. J Neurosurg 2016;124(5):1250–1256.
9. Jankowitz BT, Jadhav AP, Gross B, et al. Pivotal trial of the Neuroform Atlas stent for treatment of posterior circulation aneurysms: one-year outcomes. J Neurointerv Surg 2022;14(2):143–148.
10. Hanel RA, Kallmes DF, Lopes DK, et al. Prospective study on embolization of intracranial aneurysms with the pipeline device: the PREMIER study 1 year results. J Neurointerv Surg 2020;12(1):62–66.